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**Farrell et al.**

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(54) **SPARK PLUG**

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(60) Provisional application No. 61/509,270, filed on Jul. 19, 2011.

(51) **Int. Cl.**

| | |
|---|---|
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| ***H01T 13/32*** | (2006.01) |
| ***H01T 13/20*** | (2006.01) |
| ***F02P 13/00*** | (2006.01) |

(52) **U.S. Cl.**

CPC ..... ***H01T 13/20*** (2013.01); ***F02P 13/00*** (2013.01); ***H01T 13/32*** (2013.01); ***H01T 13/467*** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01T 13/20–13/39; H01T 13/46–13/467
USPC ..... 313/138, 139, 141–145
See application file for complete search history.

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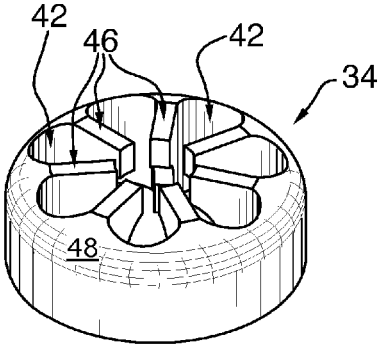
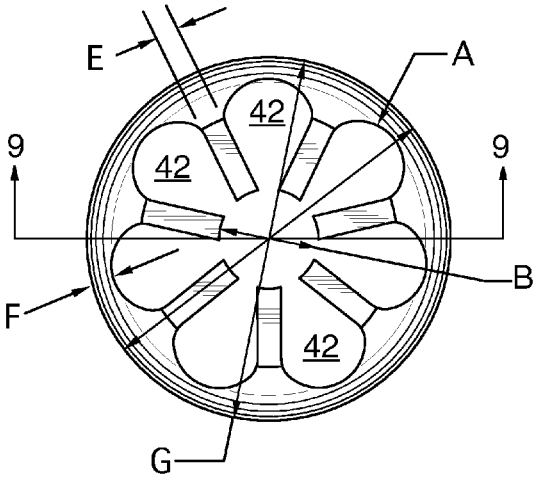
(57) **ABSTRACT**

The plug comprises a nut, a coupling extending from the nut and adapted to receive an ignition wire and an insulator extending from the nut and away from the coupling. A positive electrode extends through the insulator. An externally-threaded tubular portion extends from the nut in surrounding relation to the insulator and terminating, short of the insulator end, in a cap that is disposed in spaced relation to the insulator. The cap defines a void having: a central portion into which the positive electrode extends; an annular channel surrounding the central portion; and a plurality of lobes, each positioned with respect to the central portion as the planet gears are positioned with respect to the sun gear in a planetary gear. The cap has a central surface that is axially spaced from the insulator and a convex surface that surrounds and extends to the central surface.

**5 Claims, 4 Drawing Sheets**



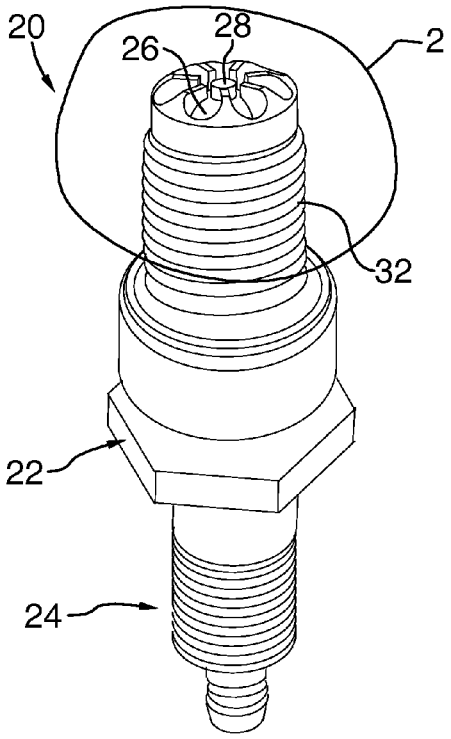



FIG.1

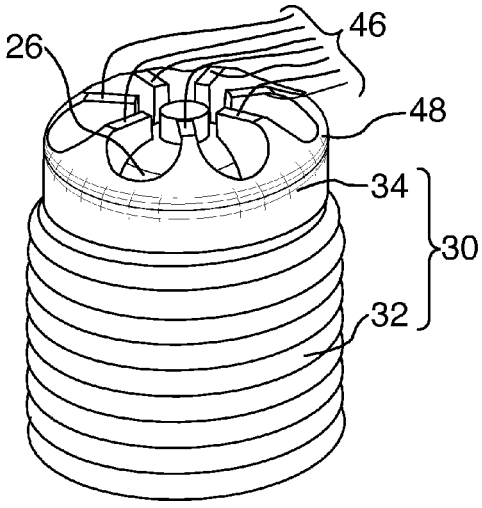



FIG.2

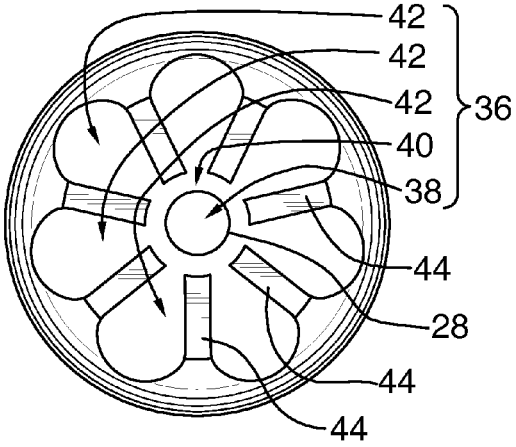



FIG.3

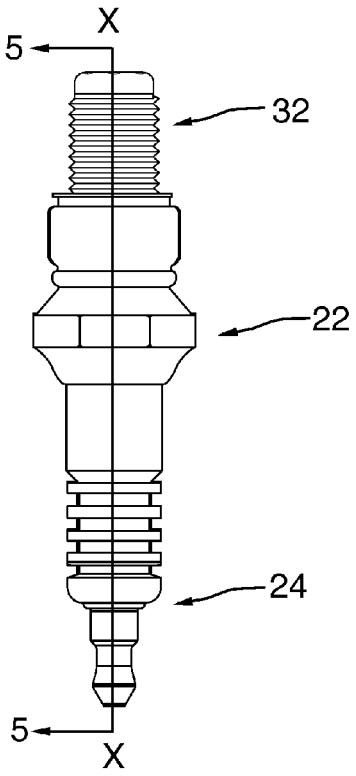



FIG.4

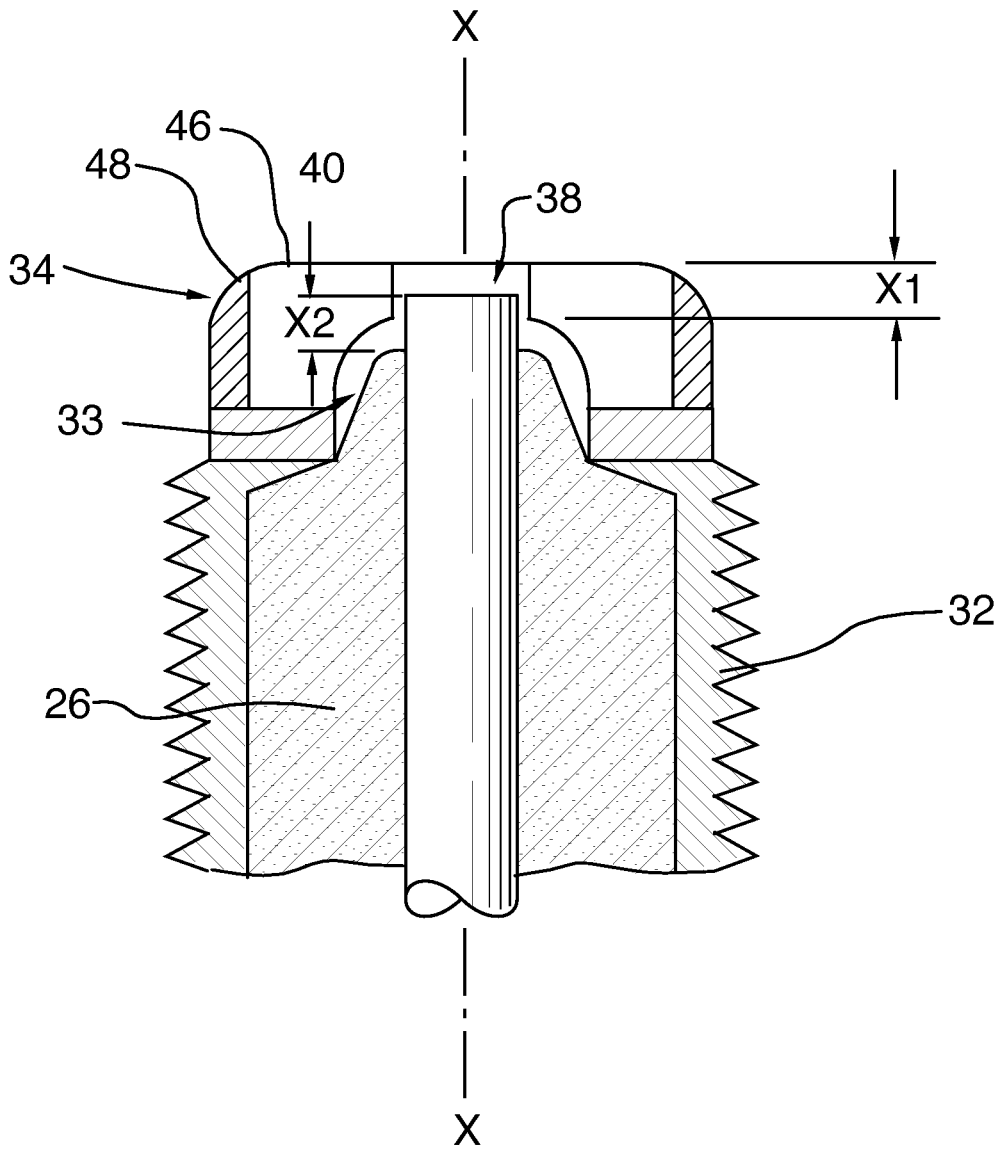



FIG.5

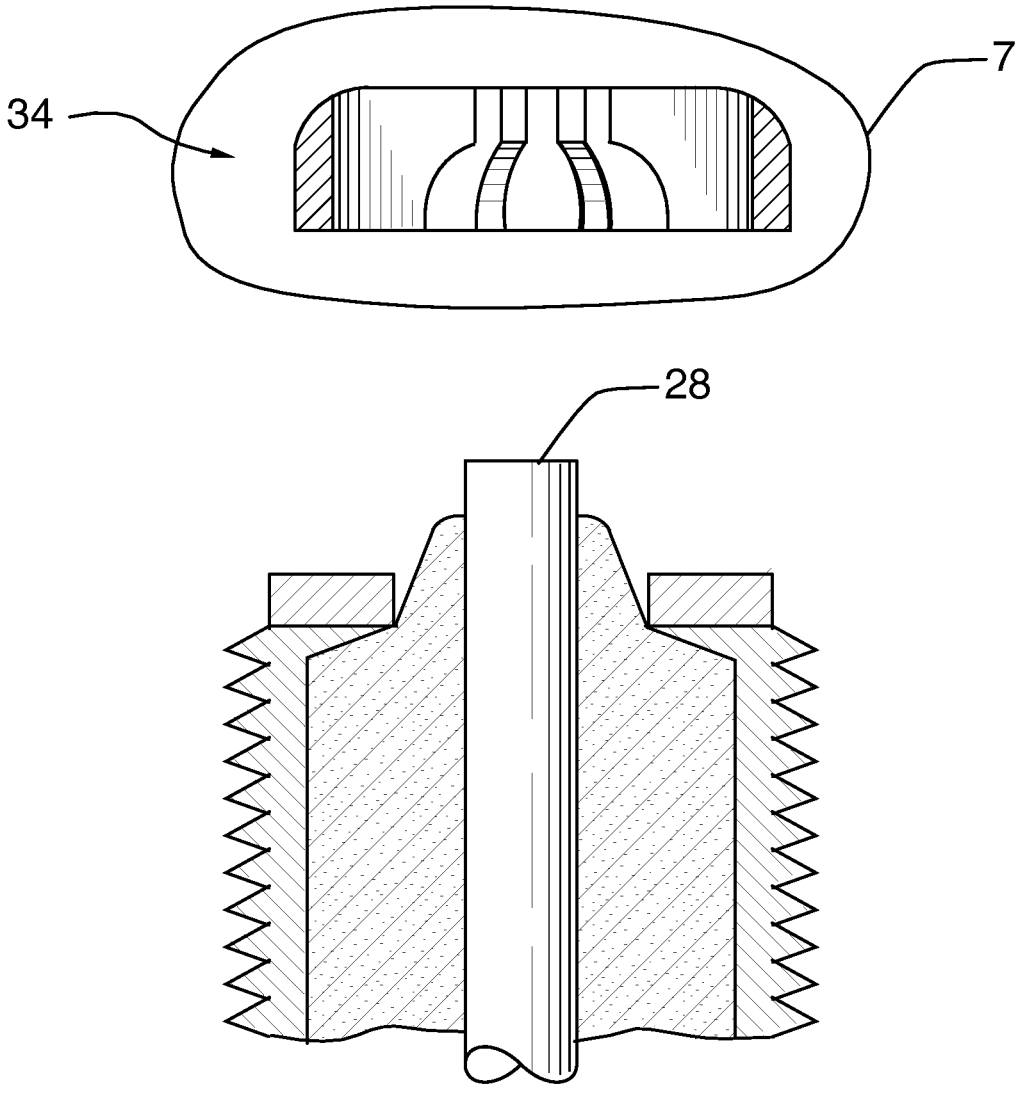



FIG.6

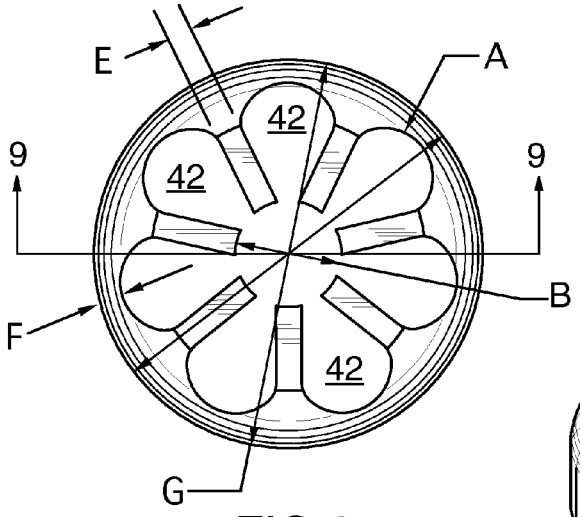



FIG.8

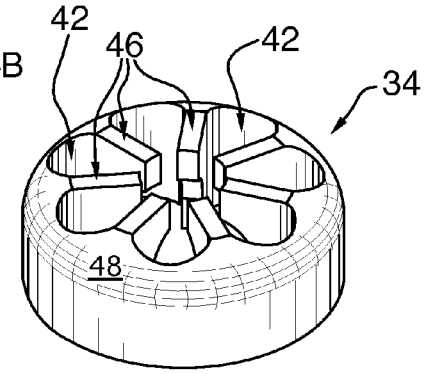



FIG.7

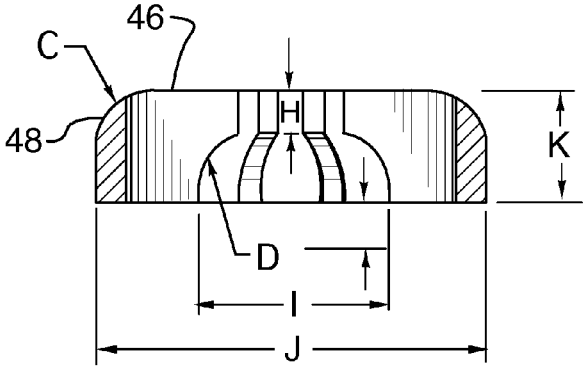



FIG.9

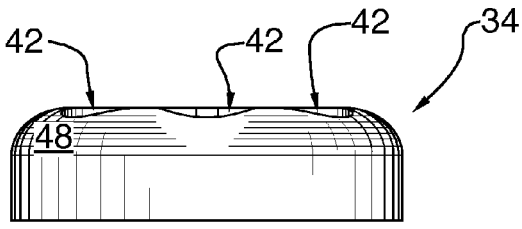



FIG.10

# SPARK PLUG

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. patent application Ser. No. 14/233,522, filed Apr. 28, 2014, which is national stage entry application of PCT/CA2011/001184, filed Oct. 24, 2011, which claims priority of U.S. Provisional Application No. 61/509,270, filed Jul. 19, 2011, all of which are incorporated herein in their entirety by reference.

## FIELD OF THE INVENTION

The present invention relates to spark-ignited internal combustion engines.

## BACKGROUND OF THE INVENTION

In internal combustion engines, it is conventional to initiate combustion with the use of spark plugs. In conventional spark plugs, a body which defines a longitudinal axis is provided. The body has, adjacent one end thereof, a metal ring which is orientated coaxially with the longitudinal axis. The body further includes a metal tube which: is orientated coaxially with the longitudinal axis; extends from the ring towards the other end of the body; and is externally-threaded for engagement in a corresponding threaded bore in an engine block in use. A porcelain insulator also forms part of the body. The insulator has a portion disposed inside the tube. This portion extends axially, from inside the tube, beyond the ring, and has an elongate void extending axially therethrough. An elongate positive electrode occupies the void and extends axially beyond the insulator to a terminus which defines the one end of the body. Conventional spark plugs also include an electrode leg. The electrode leg has two arms transversely connected to one another, with one arm extending axially from the ring and beyond the electrode and the other arm extending radially inwardly from the one arm so as to terminate in an end portion that is axially-spaced from the terminus. The spark gap in this conventional plug is the space defined between the positive electrode and the electrode leg.

## SUMMARY OF THE INVENTION

A spark plug forms one aspect of the invention. The plug, which is for use with an engine block/cylinder head having a threaded bore and is also for use with a spark plug wrench and an ignition wire, comprises a nut portion, a coupling portion, an insulator portion, a positive electrode and a ground electrode. The nut portion is adapted to be turned by the wrench. The coupling portion extends from the nut portion and is adapted to receive the ignition wire. The insulator portion extends from the nut portion and away from the coupling portion to an end. The positive electrode extends through and beyond the end of the insulator portion. The ground electrode includes a tubular metal portion and a cap portion to which the tubular portion extends. The tubular metal portion: extends from the nut portion in circumferentially surrounding relation to the insulator portion; terminates such that a portion of the insulator portion extends beyond the tubular metal portion; is orientated coaxially about and defines a longitudinal axis; and is externally-threaded for engagement in the threaded bore in said engine block in use. The cap portion is disposed in spaced relation to the insulator portion and defines a void having: a central portion into which the positive electrode extends; an annular channel surrounding the central portion; and a plurality of lobes, each being positioned with respect to the central portion in a manner analogous to the placement of the planet gears with respect to the sun gear in a planetary gear. The cap also has a central surface that is axially spaced from that portion of the insulator that protrudes beyond the tubular metal portion; and a convex surface that surrounds and extends to the central surface.



According to another aspect of the invention, the central surface can be orientated substantially normally to the longitudinal axis and substantially coplanar with the end of the positive electrode.

According to another aspect of the invention, the plurality of lobes can consist of three to seven lobes.

According to another aspect of the invention, if
R1 is the radius of each planet gear
R2 is the distance from the axis of each planet gear to the axis of the sun gear
R3 is the outer radius of the ground electrode
R4 is the outer radius of the annular channel
then
R1:R2:R3:R4:R5 can be about 0.12:0.305:0.475:0.25

According to another aspect of the invention, the plurality of lobes can consist of seven lobes.

According to another aspect of the invention, the cap portion can have radially inwardly disposed fingers which separate the lobes from one another, each finger having a terminus to which said each finger extends, the thickness of the finger at the terminus as measured in the longitudinal direction being substantially equal to the length of that portion of the positive electrode that extends beyond the insulation.

Other advantages, features and characteristics of the present invention, as well as methods of operation and functions of the related elements of the structure, and the combination of parts and economies of manufacture, will become more apparent upon consideration of the following detailed description and the appended claims with reference to the accompanying drawings, the latter being briefly described hereinafter.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a spark plug according to an exemplary embodiment of the invention

FIG. **2** is an enlarged view of encircled area **2** of FIG. **1**

FIG. **3** is an end view of the structure of FIG. **1**;

FIG. **4** is a side view of the structure of FIG. **1**;

FIG. **5** is a view along **5**-**5** of FIG. **4**; and

FIG. **6** is a view similar to FIG. **5**, illustrative of an exemplary method of manufacture;

FIG. **7** is a perspective view of encircled area **7** of FIG. **6**;

FIG. **8** is a plan view of the structure of FIG. **7**;

FIG. **9** is a view along **9**-**9** of FIG. **8**; and

FIG. **10** is a side view of the structure of FIG. **7**.

## DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENT

As an initial matter, the spark plug **20** according to the exemplary embodiment shown in FIGS. **1**-**4** is for use with an engine block/cylinder head having a threaded bore and also for use with a spark plug wrench and an ignition wire, all as is conventional.

The plug **20** also comprises, as is conventional, a nut portion **22**, a coupling portion **24**, an insulator portion **26**, a positive electrode **28** and a ground electrode **30**.

As is conventional: the nut portion **22** is adapted to be turned by the wrench; the coupling portion **24** extends from

the nut portion **22** and is adapted to receive the ignition wire; the insulator portion **26** extends from the nut portion **22** and away from the coupling portion **24** to an end; the positive electrode **28** extends through and beyond the end of the insulator portion **26**. Also as is conventional, the ground electrode **30** includes a tubular metal portion **32** which: extends from the nut portion **22** in surrounding relation to the insulator portion **26**; terminates such that a portion **33** of the insulator portion **26** extends beyond the tubular metal portion **32**; is orientated coaxially about and defines a longitudinal axis X-X and is externally-threaded for engagement in the threaded bore in said engine block in use.

However, in this spark plug, there is provided a cap portion **34** to which the tubular portion **32** extends and is circumferentially connected.

The cap portion **34**:

is disposed in spaced relation to the insulator **26** and defines a void **36** having: a central portion **38** into which the positive electrode **28** extends; an annular channel **40** surrounding central portion **38**; and a plurality of lobes **42**, each being positioned with respect to the central portion **38** in a manner analogous to the placement of the planet gears with respect to the sun gear in a planetary gear.

has a plurality of radially inwardly disposed fingers **44** which separate the lobes **42** from one another, each finger **44** having a terminus to which said each finger extends, the thickness X1 of the finger at the terminus as measured in the longitudinal direction being substantially equal to the length X2 of that portion of the positive electrode that extends beyond the insulation

has: (i) a central surface **46** that is axially spaced from that portion of the insulator **26** that protrudes beyond the tubular portion **32** and is orientated substantially normally to the longitudinal axis X-X and substantially coplanar with the end of the positive electrode **28**; and (ii) a convex surface **48** that surrounds and extends from the tubular metal portion **32** to the central surface **46**.

The geometry of the cap portion is such that if R1 is the radius of each planet gear, R2 is the distance from the axis of each planet gear to the axis of the sun gear, R3 is the outer radius of the ground electrode and R4 is the outer radius of the annular channel, then R1:R2:R3:R4:R5 is about 0.12:0.305:0.475:0.25

The spark plug of the exemplary embodiment has proven to be of substantial advantage in numerous tests that have been carried out.

TABLE 1

| Autolite AR3932X | | | modified AR3932X | | | Gains | |
|---|---|---|---|---|---|---|---|
| RPM | Torque. Lb/FT | HP | RPM | Torque. Lb/FT | HP | Gain In Torque Lb/Ft | Gain In HP |
| 5500 | 444.4 | 502.1 | 5500 | 448.3 | 506.2 | +3.9 | +4.1 |
| 5600 | 448.8 | 516.4 | 5600 | 453.8 | 521.9 | +5.0 | +5.5 |
| 5700 | 450.2 | 527.3 | 5700 | 455.3 | 532.9 | +5.1 | +5.6 |
| 5800 | 451.1 | 537.9 | 5800 | 456.8 | 544.3 | +5.7 | +6.1 |
| 5900 | 451.8 | 548.0 | 5900 | 457.7 | 554.8 | +5.9 | +6.8 |
| 6000 | 451.8 | 557.5 | 6000 | 457.3 | 563.9 | +5.5 | +6.4 |
| 6100 | 450.8 | 565.5 | 6100 | 457.2 | 573.2 | +6.4 | +7.7 |
| 6200 | 449.9 | 573.9 | 6200 | 456.8 | 582.3 | +6.9 | +8.4 |
| 6300 | 449.2 | 582.3 | 6300 | 455.7 | 590.3 | +6.5 | +8.0 |
| 6400 | 448.1 | 590.4 | 6400 | 453.7 | 597.4 | +5.6 | +7.0 |
| 6500 | 446.3 | 597.3 | 6500 | 451.7 | 604.1 | +5.4 | +6.8 |
| 6600 | 444.1 | 603.8 | 6600 | 448.7 | 609.7 | +4.6 | +5.9 |
| 6700 | 441.6 | 609.6 | 6700 | 444.3 | 613.0 | +2.7 | +3.4 |
| 6800 | 438.4 | 614.5 | 6800 | 440.7 | 617.4 | +2.3 | +2.9 |
| 6900 | 435.8 | 619.9 | 6900 | 437.5 | 622.0 | +1.7 | +2.1 |
| 7000 | 432.0 | 623.9 | 7000 | 434.0 | 626.4 | +2.0 | +2.5 |

TABLE 1-continued

| Autolite AR3932X | | | modified AR3932X | | | Gains | |
|---|---|---|---|---|---|---|---|
| RPM | Torque. Lb/FT | HP | RPM | Torque. Lb/FT | HP | Gain In Torque Lb/Ft | Gain In HP |
| 7100 | 427.6 | 626.4 | 7100 | 430.5 | 630.3 | +2.9 | +3.9 |
| 7200 | 423.1 | 629.0 | 7200 | 425.9 | 632.8 | +2.8 | +3.8 |
| 7300 | 418.5 | 631.0 | 7300 | 421.1 | 634.5 | +2.6 | +3.5 |
| 7400 | 412.9 | 631.6 | 7400 | 415.4 | 635.0 | +2.5 | +3.4 |
| 7500 | 406.5 | 630.4 | 7500 | 408.9 | 633.7 | +2.4 | +3.3 |
| 7600 | 399.5 | 628.3 | 7600 | 402.5 | 632.7 | +3.0 | +4.4 |
| 7700 | 392.4 | 625.5 | 7700 | 395.6 | 630.2 | +3.2 | +4.7 |
| 7800 | 385.7 | 623.4 | 7800 | 389.3 | 628.8 | +3.6 | +5.4 |
| 7900 | 379.2 | 621.0 | 7900 | 383.8 | 628.0 | +4.6 | +7.0 |
| 8000 | 372.0 | 617.6 | 8000 | 377.2 | 625.8 | +5.2 | +8.2 |

Table 1 shows dynamometer tests carried out using a CRA Super Series Template 360 Chev Racing Engine with a 9:1 compression. Timing was set at 34. The carburetor used was a Holly 390 with 77 jets. Oil used was 15/40 viscosity. Fuel octane: 110. Load factor was set at 1.21. The left columns show developed torque and HP at RPM values between 5500 and 8000 using a set of new, standard Autolite AR3932X plugs. The middle columns shows the same data set for the same plugs, modified with the inventive cap portion. The right columns shown the torque and horsepower gains, which manifest at all measured speeds.

TABLE 2

| OE Autolite AR473 | | | Modified AR473 | | | Gain | |
|---|---|---|---|---|---|---|---|
| RPM | Torque. Lb/FT | HP | RPM | Torque. Lb/FT | HP | Gain In Torque | Gain In HP |
| 4500 | 428.7 | 391.1 | 4500 | 447.5 | 401.6 | +18.8 | +10.5 |
| 4600 | 435.2 | 406 | 4600 | 449.6 | 412.6 | +14.4 | +6.6 |
| 4700 | 436 | 415.6 | 4700 | 449.8 | 421.7 | +13.8 | +6.1 |
| 4800 | 437 | 425.5 | 4800 | 450.6 | 431.6 | +13.6 | +6.1 |
| 4900 | 437.9 | 435.3 | 4900 | 450.6 | 440.6 | +12.7 | +5.3 |
| 5000 | 437.8 | 444.3 | 5000 | 451.3 | 450.4 | +13.5 | +6.1 |
| 5100 | 437.2 | 452.5 | 5100 | 450.2 | 458.3 | +13 | +5.8 |
| 5200 | 436 | 460.3 | 5200 | 448.5 | 465.7 | +12.5 | +5.4 |
| 5300 | 434.9 | 468 | 5300 | 445.5 | 471.5 | +10.6 | +3.5 |
| 5400 | 432.9 | 474.9 | 5400 | 442.7 | 477.5 | +9.8 | +2.9 |
| 5500 | 429.5 | 479.9 | 5500 | 439.8 | 483.2 | +10.3 | +3.3 |
| 5600 | 425.8 | 484.7 | 5600 | 437.1 | 489.2 | +11.3 | +4.5 |
| 5700 | 422 | 489 | 5700 | 432.6 | 492.8 | +10.6 | +3.8 |
| 5800 | 418.7 | 494 | 5800 | 429.1 | 497.7 | +10.4 | +3.7 |
| 5900 | 413.9 | 496.8 | 5900 | 426 | 502.6 | +12.1 | +5.8 |
| 6000 | 409.8 | 501 | 6000 | 421.2 | 505.6 | +11.4 | +4.6 |
| 6100 | 404.3 | 502 | 6100 | 416.7 | 508.6 | +12.4 | +6.6 |
| 6200 | 399.3 | 504 | 6200 | 411 | 510.1 | +11.7 | +6.1 |
| 6300 | 394.6 | 507 | 6300 | 405.1 | 511 | +10.5 | +4 |
| 6400 | 388.2 | 507 | 6400 | 399.1 | 511.7 | +10.9 | +4.7 |
| 6500 | 381.1 | 505 | 6500 | 392.7 | 511.4 | +11.6 | +6.4 |

Table 2 shows dynamometer tests carried out using a NASCAR-approved, NCATS Series Restricted 1⅛" engine with 10:1 compression. Timing was set at 30. The carburetor used was a Holly 390 with 64/64 jets. Oil used was 15/40 viscosity. Fuel octane: 94. Load factor was set at 1.21. The left columns show developed torque and HP at RPM values between 4500 and 6500 using a set of new, standard Autolite AR473 plugs. The middle columns show the same data set for the same plugs, modified with the inventive cap portion. The right columns shown the torque and horsepower gains, which manifest all at all measured speeds.

TABLE 3

| Autolite AR3932X | | | modified AR3932X | | | Gains | |
|---|---|---|---|---|---|---|---|
| RPM | Torque. Lb/FT | HP | RPM | Torque. Lb/FT | HP | Gain In Torque Lb/Ft | Gain In HP |
| 4500 | 667.0 | 572.0 | 4500 | 667.0 | 572.0 | +0.0 | +0.0 |
| 4600 | 671.0 | 587.0 | 4600 | 671.0 | 588.0 | +0.0 | +1.0 |
| 4700 | 673.0 | 603.0 | 4700 | 677.0 | 605.0 | +4.0 | +2.0 |
| 4800 | 676.0 | 618.0 | 4800 | 682.0 | 623.0 | +6.0 | +5.0 |
| 4900 | 678.0 | 632.0 | 4900 | 684.0 | 638.0 | +6.0 | +6.0 |
| 5000 | 678.0 | 645.0 | 5000 | 686.0 | 653.0 | +8.0 | +8.0 |
| 5100 | 679.0 | 660.0 | 5100 | 686.0 | 666.0 | +7.0 | +6.0 |
| 5200 | 682.0 | 675.0 | 5200 | 686.0 | 679.0 | +4.0 | +4.0 |
| 5300 | 685.0 | 691.0 | 5300 | 689.0 | 695.0 | +4.0 | +4.0 |
| 5400 | 688.0 | 708.0 | 5400 | 691.0 | 711.0 | +3.0 | +3.0 |
| 5500 | 691.0 | 724.0 | 5500 | 692.0 | 724.0 | −1.0 | +0.0 |
| 5600 | 694.0 | 740.0 | 5600 | 693.0 | 739.0 | −1.0 | −1.0 |
| 5700 | 695.0 | 754.0 | 5700 | 694.0 | 753.0 | −1.0 | −1.0 |
| 5800 | 694.0 | 766.0 | 5800 | 695.0 | 768.0 | +1.0 | +2.0 |
| 5900 | 690.0 | 775.0 | 5900 | 695.0 | 781.0 | +5.0 | +6.0 |
| 6000 | 688.0 | 786.0 | 6000 | 692.0 | 791.0 | +4.0 | +5.0 |
| 6100 | 684.0 | 795.0 | 6100 | 688.0 | 799.0 | +4.0 | +4.0 |
| 6200 | 682.0 | 805.0 | 6200 | 685.0 | 809.0 | +4.0 | +5.0 |
| 6300 | 678.0 | 813.0 | 6300 | 681.0 | 817.0 | +3.0 | +4.0 |
| 6400 | 671.0 | 818.0 | 6400 | 677.0 | 825.0 | +6.0 | +7.0 |
| 6500 | 663.0 | 821.0 | 6500 | 670.0 | 830.0 | +7.0 | +9.0 |
| 6600 | 654.0 | 822.0 | 6600 | 663.0 | 833.0 | +9.0 | +9.0 |
| 6700 | 644.0 | 822.0 | 6700 | 653.0 | 834.0 | +9.0 | +12.0 |
| 6800 | 636.0 | 824.0 | 6800 | 646.0 | 837.0 | +10.0 | +13.0 |
| 6900 | 626.0 | 822.0 | 6900 | 636.0 | 835.0 | +10.0 | +12.0 |
| 7000 | 615.0 | 820.0 | 7000 | 626.0 | 834.0 | +11.0 | +14.0 |

Table 3 shows dynamometer tests carried out using a Chevy Big Block at 12:1 Compression. Timing was set at 32. The carburetor used was a Holly 850 with 77 jets. Oil used was 15/40 viscosity. Fuel octane: 110. Load factor was set at 0.77. The left columns show developed torque and HP at RPM values between 4500 and 7000 using a set of new, standard Autolite AR3932X plugs. The middle columns show the same data set for the same plugs, modified with the inventive cap portion. The right columns shown the torque and horsepower gains, which manifest at all but 5500-5700 RPM.

TABLE 4

| Autolite AR3932X | | | modified AR3932X (.045 gap) | | | Gains | |
|---|---|---|---|---|---|---|---|
| RPM | Torque. Lb/FT | HP | RPM | Torque. Lb/FT | HP | Gain In Torque Lb/Ft | Gain In HP |
| 4500 | 667.0 | 572.0 | 4500 | 668.0 | 572.0 | +1.0 | +0.0 |
| 4600 | 671.0 | 587.0 | 4600 | 672.0 | 588.0 | +1.0 | +1.0 |
| 4700 | 673.0 | 603.0 | 4700 | 678.0 | 607.0 | +5.0 | +4.0 |
| 4800 | 676.0 | 618.0 | 4800 | 681.0 | 623.0 | +5.0 | +5.0 |
| 4900 | 678.0 | 632.0 | 4900 | 681.0 | 635.0 | +3.0 | +3.0 |
| 5000 | 678.0 | 645.0 | 5000 | 680.0 | 647.0 | +2.0 | +2.0 |
| 5100 | 679.0 | 660.0 | 5100 | 679.0 | 659.0 | +0.0 | −1.0 |
| 5200 | 682.0 | 675.0 | 5200 | 680.0 | 673.0 | −2.0 | −2.0 |
| 5300 | 685.0 | 691.0 | 5300 | 688.0 | 694.0 | +3.0 | +3.0 |
| 5400 | 688.0 | 708.0 | 5400 | 689.0 | 708.0 | +1.0 | +0 |
| 5500 | 691.0 | 724.0 | 5500 | 690.0 | 723.0 | −1.0 | +1.0 |
| 5600 | 694.0 | 740.0 | 5600 | 693.0 | 739.0 | −1.0 | −1.0 |
| 5700 | 695.0 | 754.0 | 5700 | 695.0 | 754.0 | +0.0 | +0 |
| 5800 | 694.0 | 766.0 | 5800 | 693.0 | 765.0 | −1.0 | −1.0 |
| 5900 | 690.0 | 775.0 | 5900 | 692.0 | 778.0 | +2.0 | +3.0 |
| 6000 | 688.0 | 786.0 | 6000 | 692.0 | 790.0 | +4.0 | +4.0 |
| 6100 | 684.0 | 795.0 | 6100 | 690.0 | 801.0 | +6.0 | +6.0 |
| 6200 | 682.0 | 805.0 | 6200 | 686.0 | 810.0 | +4.0 | +5.0 |
| 6300 | 678.0 | 813.0 | 6300 | 681.0 | 816.0 | +3.0 | +3.0 |
| 6400 | 671.0 | 818.0 | 6400 | 677.0 | 825.0 | +6.0 | +7.0 |
| 6500 | 663.0 | 821.0 | 6500 | 670.0 | 829.0 | +7.0 | +8.0 |
| 6600 | 654.0 | 822.0 | 6600 | 661.0 | 831.0 | +7.0 | +9.0 |
| 6700 | 644.0 | 822.0 | 6700 | 653.0 | 833.0 | +9.0 | +11.0 |
| 6800 | 636.0 | 824.0 | 6800 | 644.0 | 834.0 | +8.0 | +10.0 |

TABLE 4-continued

| Autolite AR3932X | | | modified AR3932X (.045 gap) | | | Gains | |
|---|---|---|---|---|---|---|---|
| RPM | Torque. Lb/FT | HP | RPM | Torque. Lb/FT | HP | Gain In Torque Lb/Ft | Gain In HP |
| 6900 | 626.0 | 822.0 | 6900 | 635.0 | 834.0 | +9.0 | +12.0 |
| 7000 | 615.0 | 820.0 | 7000 | 627.0 | 836.0 | +12.0 | +16.0 |

Table 4 shows dynamometer tests carried out using a Chevy Big Block at 12:1 Compression, 0.045 gap. Timing was set at 32. The carburetor used was a Holly 850 with 77 jets. Oil used was 15/40 viscosity. Fuel octane: 110. Load factor was set at 0.77. The left columns show developed torque and HP at RPM values between 4500 and 7000 using a set of new, standard Autolite AR3932X plugs. The middle columns show the same data set for the same plugs, modified with the inventive cap portion. The right columns shown the torque and horsepower gains, which manifest at all but 5500-5800 RPM.

TABLE 5

HORSE POWER COMPARISON

| OE AR3932X | | | | | NS AR3932X | | | |
|---|---|---|---|---|---|---|---|---|
| #1 HP OE | #2 HP OE | #3 HP OE | Average OE HP | RPM | Average NS HP | #1 HP NS | #2 HP NS | #3 HP NS |
| 572 | 569 | 571 | 570.6 | 4500 | 572 | 571 | 572 | 573 |
| 587 | 583 | 587 | 585.6 | 4600 | 587.6 | 588 | 588 | 587 |
| 603 | 599 | 604 | 602 | 4700 | 604.3 | 605 | 605 | 603 |
| 618 | 615 | 621 | 618 | 4800 | 621.3 | 622 | 623 | 619 |
| 632 | 629 | 636 | 632.3 | 4900 | 636.3 | 637 | 638 | 634 |
| 645 | 642 | 650 | 645.6 | 5000 | 650.3 | 651 | 653 | 647 |
| 660 | 655 | 662 | 659 | 5100 | 664.3 | 665 | 666 | 662 |
| 675 | 671 | 676 | 674 | 5200 | 678.6 | 680 | 679 | 677 |
| 691 | 689 | 692 | 690.6 | 5300 | 693.6 | 692 | 695 | 694 |
| 708 | 706 | 707 | 707 | 5400 | 709.6 | 708 | 711 | 710 |
| 724 | 723 | 724 | 723.6 | 5500 | 724.3 | 723 | 724 | 726 |
| 740 | 740 | 741 | 740.3 | 5600 | 740 | 739 | 739 | 742 |
| 754 | 754 | 755 | 754.3 | 5700 | 755 | 754 | 753 | 758 |
| 766 | 764 | 768 | 766 | 5800 | 767.6 | 765 | 768 | 770 |
| 775 | 774 | 778 | 775.6 | 5900 | 780.3 | 778 | 781 | 782 |
| 786 | 783 | 789 | 786 | 6000 | 791.6 | 790 | 791 | 794 |
| 795 | 794 | 797 | 795.3 | 6100 | 801.6 | 801 | 799 | 805 |
| 805 | 806 | 806 | 805.6 | 6200 | 811.6 | 810 | 809 | 816 |
| 813 | 814 | 813 | 813.3 | 6300 | 818.6 | 816 | 817 | 823 |
| 818 | 819 | 819 | 818.6 | 6400 | 826 | 825 | 825 | 828 |
| 821 | 823 | 825 | 823 | 6500 | 830.6 | 829 | 830 | 833 |
| 822 | 826 | 828 | 825.3 | 6600 | 833 | 831 | 833 | 835 |
| 822 | 828 | 830 | 826.6 | 6700 | 834.3 | 833 | 834 | 836 |
| 824 | 827 | 828 | 826.3 | 6800 | 836 | 834 | 837 | 837 |
| 822 | 826 | 824 | 824 | 6900 | 835 | 834 | 835 | 836 |
| 820 | 825 | 822 | 822.3 | 7000 | 835.3 | 836 | 834 | 836 |

TABLE 6

| TORQUE COMPARISON | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| OE AR3932X | | | | | NS AR473 | | | |
| #1 TQ OE | #2 TQ OE | #3 TQ OE | Average OE TQ | RPM | Average NS TQ | #1 TQ NS | #2 TQ NS | #3 TQ NS |
| 667 | 664 | 666 | 665.6 | 4500 | 667.3 | 667 | 667 | 668 |
| 671 | 666 | 671 | 669.3 | 4600 | 671 | 672 | 671 | 670 |
| 673 | 669 | 675 | 672.3 | 4700 | 676.3 | 676 | 677 | 676 |
| 676 | 673 | 680 | 676.3 | 4800 | 680.3 | 681 | 682 | 678 |
| 678 | 674 | 682 | 678 | 4900 | 683.6 | 683 | 684 | 684 |
| 678 | 674 | 683 | 678.3 | 5000 | 686 | 684 | 686 | 688 |
| 679 | 675 | 682 | 678.6 | 5100 | 685 | 685 | 686 | 684 |
| 682 | 678 | 683 | 681 | 5200 | 685.6 | 687 | 686 | 684 |
| 685 | 682 | 685 | 684 | 5300 | 688.3 | 688 | 689 | 688 |
| 688 | 687 | 688 | 687.6 | 5400 | 690 | 689 | 691 | 690 |
| 691 | 690 | 691 | 690.6 | 5500 | 691.6 | 690 | 692 | 693 |
| 694 | 694 | 695 | 694.3 | 5600 | 694 | 693 | 693 | 696 |
| 695 | 695 | 696 | 695.3 | 5700 | 695.6 | 695 | 694 | 698 |
| 694 | 692 | 695 | 693.6 | 5800 | 695 | 693 | 695 | 697 |
| 690 | 689 | 692 | 690.3 | 5900 | 694.3 | 692 | 695 | 696 |
| 688 | 686 | 690 | 688 | 6000 | 693 | 692 | 692 | 695 |
| 684 | 684 | 687 | 685 | 6100 | 690.3 | 690 | 688 | 693 |
| 682 | 683 | 683 | 682.6 | 6200 | 687.3 | 686 | 685 | 691 |
| 678 | 678 | 678 | 678 | 6300 | 682.6 | 681 | 681 | 686 |
| 671 | 672 | 672 | 671.6 | 6400 | 677.6 | 677 | 677 | 679 |
| 663 | 665 | 666 | 664.6 | 6500 | 671 | 670 | 670 | 673 |
| 654 | 657 | 659 | 656.6 | 6600 | 663 | 661 | 663 | 665 |
| 644 | 649 | 651 | 648 | 6700 | 653.6 | 653 | 653 | 655 |
| 636 | 639 | 640 | 638.3 | 6800 | 645.6 | 644 | 646 | 647 |
| 626 | 629 | 628 | 627.6 | 6900 | 635.6 | 635 | 636 | 636 |
| 615 | 619 | 617 | 617 | 7000 | 626.6 | 627 | 626 | 627 |

Tables 5 and 6 show dynamometer tests for a Chevy Big Block. Timing was set at 32. The carburetor used was a Holly 850 with 77/77 jets. Oil used was 15/40 viscosity. Fuel octane: 110. Load factor was set at 0.77. In Table 5, the three left columns show developed horsepower at RPM between 4500 and 7000 using a set of new AR3932X plugs. The three right columns show the same data for the same plugs, modified with the inventive cap portion. Horsepower gains were obtained at all speeds but for 5600 RPM. In Table 6, the three left columns show developed torque at RPM between 4500 and 7000 using a set of new AR3932X plugs. The three right columns show the same data for the same plugs, modified with the inventive cap portion. Torque gains were obtained at all speeds but for 5600 RPM

In each of the examples, reference is made to plugs that have been modified with the inventive cap portion. In this regard, it will be appreciated that, in each case, the reference/baseline plug mentioned was modified by grinding off the electrode leg thereof and welding a ring thereto, as illustrated by FIG. **6**.

An exemplary ring is shown in FIGS. **7-10**. This ring is produced from 304 2B stainless steel and is dimensioned as follows:

| | |
|---|---|
| A | .060 radius |
| B | .13" |
| C | .07" radius |
| D | .076R |
| E | .031" |
| F | .028" |
| G | .47" |
| H | .05" |
| I | .24" |
| J | .47" |
| K | .13" |

However, it will be understood that these dimensions were selected such that the distance between the positive electrode and the ring is the distance specified by the manufacturer of the vehicle with which the modified plug was used. Variation from these dimensions are possible and indeed would be adopted in other engine applications to meet the specifications of the engine manufacturer.

Further, whereas a seven lobe structure is disclosed, the plurality of lobes can consist of three to seven lobes.

Accordingly, it should be understood that the invention is to be limited only by the accompanying claims, purposively construed.

The invention claimed is:

**1**. A spark plug for use with an engine block/cylinder head having a threaded bore and also for use with a spark plug wrench and an ignition wire, the plug comprising:

a nut portion adapted to be turned by the wrench;

a coupling portion extending from the nut portion and adapted to receive the ignition wire;

an insulator portion extending from the nut portion and away from the coupling portion to an end;

a positive electrode extending through and beyond the end of the insulator portion; and

a ground electrode including

a tubular metal portion extending from the nut portion in surrounding relation to the insulator portion, the tubular portion being orientated coaxially about and defining a longitudinal axis and further being externally-threaded for engagement in the threaded bore in said engine block in use; and

a cap portion to which the metal portion extends and disposed in spaced relation to the insulator portion, the cap portion

defining a void having: a central portion into which the positive electrode extends; an annular channel

surrounding the central portion; a plurality of lobes, each being positioned with respect to the central portion in a manner analogous to the placement of the planet gears with respect to the sun gear in a planetary gear,

having a central surface axially spaced from that portion of the insulator that protrudes beyond the tubular portion a convex surface that surrounds and extends to the central surface, and

radially inwardly disposed fingers which separate the lobes from one another, each finger having a terminus to which said each finger extends, the thickness of the finger at the terminus as measured in the longitudinal direction being substantially equal to the length of that portion of the positive electrode that extends beyond the insulation.

**2**. The spark plug according to claim **1**, wherein the central surface is orientated substantially normally to the longitudinal axis and substantially coplanar with the end of the positive electrode.

**3**. A spark plug according to claim **1**, wherein the plurality of lobes consists of three to seven lobes.

**4**. A spark plug according to claim **3**, wherein if

R1 is the radius of each planet gear

R2 is the distance from the axis of each planet gear to the axis of the sun gear

R3 is the outer radius of the ground electrode

R4 is the outer radius of the annular channel

R1:R2:R3:R4:R5 is about 0.12:0.305:0.475:0.25.

**5**. A spark plug according to claim **4**, wherein the plurality of lobes consists of seven lobes.

* * * * *